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IV. *Account of a Petrefaction found on the Coast of East Lothian.* By Edward King, Esq. F. R. S.

TO SIR JOHN PRINGLE, BART. P. R. S.

S I R,

John-street,
November 14, 1778.

Read Nov. 26, 1778. **I**N consequence of the honour you did me, to put into my hands a very curious specimen of a recent petrefaction, permit me now to offer to your consideration a few thoughts concerning this production, which have occurred to me on comparing it with others of a similar kind, and which may at least serve as hints for further investigation.

We should not venture, it is true, without great caution, to speculate on these matters, as hasty and specious conclusions may easily be drawn by any one who indulges too readily a quick and lively imagination, which will ever be too ready to mislead, rather than to procure solid information. But though I

am well aware of this danger, yet I venture to lay before you these few observations; and if you judge them at all worthy of attention, I would wish to communicate them, through your hands, to the Royal Society, for they are not made merely in consequence of a slight and hasty survey of this one specimen, but are in truth conclusions that I have been led to form incidentally in the course of a very long inquiry, which I have been for some years pursuing on another occasion; the result whereof I shall perhaps, if I live, hereafter communicate to the Society in a more full and explicit manner than the compass of a paper of this kind will permit.

The account of this specimen, with which you favoured me, is as follows. In the year 1745, the Foxman of war was unfortunately stranded on the coast of East Lothian in Scotland, and there went to pieces; and the wreck remained about three and thirty years under water; but this last year a violent storm from the North-east laid a part of it bare, and several masses, consisting of iron, ropes, and balls, were found on the sands near the place, covered over with a very hard ochry substance, of the colour of iron, which adhered thereto so strongly, that it required great force to detach it from the fragments of the wreck. And, upon examination, this substance

stance appeared to be sand, concreted and hardened into a kind of stone.

The specimen now laid before the Society had been taken out of the sea, from the same spot, some time before, and is a consolidated mass that had undergone the same change. It contains a piece of rope that was adjoining to some iron ring, and probably had been tied thereto. The substance of the rope is very little altered; but the sand is so concreted round it, as to be as hard as a bit of rock, and retains very perfectly impressions of parts of the ring, just in the same manner as impressions of extraneous fossil bodies are often found in various kinds of strata.

Now, considering these circumstances, we may fairly conclude, in the first place, that there is, on the coasts of this island, a continual progressive induration of masses of sand and other matter at the bottom of the ocean, somewhat in the same manner as there is at the bottom of the Adriatic sea, according to the account given by Dr. DONATI^(a).

And, in the next place (which is what more particularly deserves our attention on this occasion), it should seem, that iron, and the solutions of iron, contribute very much to hasten and promote the progress of the concretion and induration of stone, whenever they meet and are

(a) See the Phil. Transf. vol. XLIX. p. 588.

united with those cementing cryftalline particles, which there is reason to believe are the more immediate caufe of the confolidation of all ftones and marbles whatfoever, and which do very much abound in fea water.

It would exceed the limits of this paper, were I to attempt here to mention only a fmall part of the various facts that have come to my knowledge; and which have convinced me, and I truft, when offered fairly to the confideration of others, will make it appear fully to all that are attentive to thefe kind of refearches, that there is, to this very day, a formation of ftone, and even of marble itfelf, in certain places, in a much more perfect manner, than has been generally conceived; and far beyond what has been fuppofed, even by thofe who have been ready too haftily to account for fuch a procefs merely in confequence of obfervations made on ftalactitical and fuch like ordinary concretions.

I fhall not therefore prefume to trouble the Society, at prefent, with any detail of the inquiries I have made relating to that fubject, though in reality they have been the foundation of the obfervations made in this paper; but fhall confine my remarks merely to this one curious circumftance; that wherever there is any induration and petrefaction of matter, from any caufes whatever, it is greatly haftened in its progreff, and the confolidation is rendered much more compleat and firm by
being

being near any mafs of iron, and ftill more fo by the admixture of any folution of that metal.

This appears, in fome degree, from the prefent fpecimen; where, near adjoining to the ring, and in the portion of the fragment that has the largeft impreffion thereof, the concreted fand-ftone is of a firmer texture, and there is a larger cohering mafs formed about that part of the rope, than about thofe parts that are further removed from the ring.

It appears alfo from a circumftance that was particularly taken notice of when the wreck was difcovered by the ftorm this year (and which is mentioned, SIR, in the letter you favoured me with a fight of); for the mafles that were obferved to have thefe concretions adhering to them, were not mafles of timber, or other large fragments of the wreck, which one would think, on a flight confideration of the matter, were moft likely to caufe obftructions at the bottom of the ocean, and to form little banks of fand, that might afterwards be concreted; but they were mafles of loofe iron and ropes, and even of cannon balls, which were thus confolidated.

The fame conclufion alfo may be drawn, with ftill more appearance of its being well founded, from a very remarkable piece of antiquity, which was difcovered about three years ago on the coaft of Kent. Some fifhermen, fweeping for anchors in the Gull ftream (a part of

the sea near the Downs), drew up a very curious old swivel gun, near eight feet in length. The barrel of the gun, which was about five feet long, was of brass; but the handle (whereby it was to be turned or traversed) which was about three feet in length, and also the swivel and pivot on which it turned, were of iron, and all round these latter, and especially about the swivel and pivot, were formed exceeding hard incrustations of sand, converted into a kind of stone, of an exceeding strong texture and firmness; whereas round the barrel of the gun, except where it was near adjoining to the iron, there were no such incrustations at all, the greater part of it being clean, and in good condition, just as if it had still continued in use^(b).

The incrustation round the iron part of this gun was also the more deserving of attention, because it inclosed within it, and also held fastly adhering to it on the outside, a number of shells and corallines, just in the same manner as they are often found in a fossil state. There were plainly to be distinguished, on the outside of this mass of incrustation, pectens, cockles, limpets, muscles, *vermiculi marini* and *balini*; and besides these, one *bucci-*

(b) As there were several remarkable particularities in this gun, tending to explain some curious facts in history, I took the liberty to give a full account of it, with a view to illustrate them, in a memoir laid before the Antiquarian Society last year.

num^(c) and one oyster; and they were all so thoroughly and strongly fixed thereto, and themselves also converted into such an hard substance, that it required as much force to separate or break them, as to break a fragment off any hard rock; and in colour and appearance, they much resembled some of the masses of fossil bodies found near Chippenham in Wiltshire.

This remarkable incrustation, therefore, thus confined to the parts of the gun adjoining to the iron, and appearing no where else upon it, plainly indicates, that the iron was, by some means or other, the more immediate cause thereof: and yet it is to be observed, that in this instance the iron was very little dissolved; for although it is manifest, from some circumstances in its history, that the gun must have remained in the sea above two hundred years, and probably a great deal longer, yet the greater part of the handle and of the swivel remained entire, and even the point of the pivot was undissolved, and very visible.

Another curious appearance also, of a similar nature, will tend further to confirm the observations here made. This is found in a specimen (now in my possession) of a most remarkable incrustation, that was formed in the space of three years only, within a square wooden pipe, in a Coal Mine in Somersetshire. I gave a very particu-

(c) See the figure marked G 41.

lar account of this production in a paper laid before the Society in the year 1773^(d), and therefore shall say nothing of it here but what immediately relates to the present purpose. The pipe was forty-two feet in length, and the hollow part of it was seven inches and an half wide, by four inches and an half; and this whole cavity was so filled with the incrufted matter (which was hard enough to take an exceeding fine polish, like the most beautiful marble) that at last there was left a water way, which, nearly uniformly throughout the whole length of the pipe, was only about three inches and an half by one inch; and thus there was formed, within the first wooden pipe, a second pipe of this incrustation, the thickness of the sides of which was about one inch and an half. On cutting a transverse section of this pipe there appeared a number of uniform lines, forming almost regular similar parallelograms, one within another, like the coats of an onion, and plainly denoting the gradual and regular progress of the formation of the whole incrustation. But the circumstance most remarkable, and that is more immediately applicable to the present purpose, is, that where there was, by accident, the point of a nail projecting through the side of the wooden pipe, it so accelerated the progress of the incrustation, that, adjoining thereto, the similar sides of the first and outward

(d) Phil. Trans. vol. LXIII. p. 241.

parallelograms next the wooden pipe (instead of continuing as straight lines) formed in that place very bold semi-circular curves, or protuberances, one beyond another, projecting from the wooden pipe inwards; and this curvilinear projection was uniformly continued throughout all the similar parallelograms quite to the inward cavity of the pipe formed by the incrustation, and there at last occasioned a projecting gibbosity, of a considerable extent every way, from the point of the nail^(e).

Having mentioned these remarkable facts to my very learned and ingenious friend Dr. FOTHERGILL, I had the pleasure to find they struck him much in the same light in which they had appeared to me; and that he, moreover, formed the same conclusion concerning the specimen now laid before the Society that you had also formed and mentioned in the note you favoured me with when you sent the specimen to my house; namely, that the concretion was effected by the solution of the adjoining iron ring.

Dr. FOTHERGILL also (who had communicated some very original conjectures upon this subject to the Society many years^(f) ago) informed me of some further

(e) There is another fragment of the incrustation formed within this pipe, with a transverse section thereof polished, in the Museum of the Royal Society; but that with the point of the nail, which is here alluded to, is still in my possession.

(f) In a paper on the Origin of Amber, read in the year 1743.

curious facts, which he permits me now to mention in this paper.

On passing through the streets of London in his walks, before the sign-irons were taken down, he perceived, that on the broad stone pavements, whenever he came just under any sign-irons, his cane gave a different sound, and occasioned a different kind of resistance to the hand, from what it did elsewhere; and attending more particularly to this circumstance, he found, that every where, under the drip of those irons, the stones had acquired a greater degree of solidity, and a wonderful hardness, so as to resist any ordinary tool, and gave, when struck upon, a metallic sound: and this fact, by repeated observations, he was at length most thoroughly convinced of.

Taking the hint, therefore, from hence, he thought fit to make several experiments; and, amongst the rest, placed two pieces of Portland stone in the same aspect and situation in every respect, but washed the one frequently with water impregnated with rusty iron, and left the other untouched: and in a very few years he found the former had acquired a very sensible degree of that hardness before described, and on being struck gave the metallic sound; whilst the other remained in its original state, and subject to the decays occasioned by the changes
of

of the weather, which we find in many instances make a most rapid progress.

He also mentioned to me a very curious circumstance of his having found on the sea-coast near Scarborough, many years ago, part of an horse-shoe incrusted with sea sand, which was so concreted as to have acquired the hardness of common grit stone, and retained the colour of the sand, with very little tincture of the iron ochre: and by the part which was left free from the incrustation it appeared most probable, that the horse-shoe had not been buried there many years, but had very recently acquired this incrustation upon that part only that was most exposed to the washing of the sea water.

Now, all these facts put together scarce leave any doubt but that iron, and solutions of iron, do greatly promote and hasten the progress of all kinds of petrification; and therefore, to pursue Lord BACON's rule of induction, deducing truth from a variety of facts and experiments, all manifestly and uniformly leading us to the same conclusion, we may fairly infer, that whereas iron is of such manifest use in the progress of vegetation, that plants are indebted for their green colour^(g), and for

(g) There are some exceeding curious experiments and observations of Mr. DELAVAL's, tending to illustrate this fact, in the Phil. Trans. vol. LV. p. 36, 37.

many of their valuable qualities, to its being intimately mixed in their substance; and as it is moreover obviously useful, some way or other, in the animal system, and may be extracted by the magnet from the ashes of animal substances; so it is no less useful in the consolidation of stones and marble in the fossil world.

Mr. PRYCE, in a very useful and curious treatise of Mineralogy^(b), has moreover lately shewn it to be equally useful in the mineral world, by forming a proper *nidus* for the assemblage of the most valuable metals, and attracting and uniting them thereby. This metal, therefore, seems to be almost universally one of the greatest bands that unites the several parts of matter, and one of the most useful and important of substances in the world.

It is not for us to presume to comprehend any thing about the original formation of bodies. Such disquisitions are far out of the reach of our faculties; nor do I at all pretend to enter into them: but we are permitted to behold and consider the works of the Almighty, and may become wiser and reap profit from the contemplation of them, and may perceive in what manner many new combinations of matter are continually effected.

And as we manifestly perceive plants to grow daily for the necessary supplies of life, without knowing how

(b) Mineralogia Cornubiensis, p. 6. II. 67.

they

they grow; but yet are convinced they are nourished by means of the ſalts and particles of matter conveyed to them by water and vapour, and that iron is a neceſſary ingredient in their compoſition; ſo I am perſuaded we ſhall, at length, perceive (notwithſtanding the general opinion to the contrary) that even ſtones and marbles are ſtill continually forming in the earth for the ſervices of human life, and to ſupply the continual waſte and decay that there is of thoſe ſubſtances; and that the conſolidation of them is effected by means of water and vapour likewiſe (of which I am able to produce very many and convincing proofs); and that iron, which is what alone I wiſh now to make apparent, is unqueſtionably a principal means of effecting the induration of many of thoſe bodies.

But I would not willingly trouble the Society with this paper as a matter of mere ſpeculation. I would wiſh that ſome hint, which might be more immediately uſeful, ſhould, if poſſible, be derived therefrom; and ſuch has been ſuggeſted to me by Dr. FOTHERGILL.

If iron and the ſolutions of iron do thus contribute to the induration of bodies, ſuch ſolutions muſt probably have that tendency in every ſtage of thoſe bodies' exiſtence; and therefore it ſeems likely, that the fine ornamental carvings in Portland, or other ſtone, might be
much.

much hardened, and preserved for a much longer time than has been usual, from the injuries of the weather, by being washed and brushed over by water, in which is infused a solution of iron. And perhaps even the softer kinds of stones might have been preserved by this means; and the venerable remains of that fine pile of building HENRY the VIIIth's chapel, might have been saved from the destruction with which we now see it ready to be overwhelmed.

It is very probable, moreover, that common sea sand, with a very small admixture of a solution of iron, may at length, without any great expence, be converted into a most useful species of stone, and be applied to the purpose of covering the fronts of houses even more durably, and in as beautiful a manner as some of the late invented stuccos; and even those stuccos may be improved by means of the same mixture.

It must be left to future experiments to ascertain what proportions of the solutions of iron are best to be made use of; and in what manner the solution may best be obtained for this purpose; whether by a vitriolic acid; or merely by laying rusty iron for some time in water⁽ⁱ⁾. But one caution should be observed; namely, that if too

(i) It is not perhaps possible to contrive a less saturated tincture of iron than the rust dissolved in water.

great a proportion of vitriolic acid be left in the mixture, it may do more mischief than the iron can do good. With this caution it were perhaps much to be wished, that experiments^(b) should be made, and attended to, for a long course of years; for without such continued and repeated trials, it will be impossible to determine in what manner the application may be made with most advantage.

I have only therefore to add, that what has been said may perhaps receive some further confirmation, from considering that the chief constituent parts of all cements for stone are always lime and iron⁽ⁱ⁾; and that any experiments made in consequence of these observations will be likely to succeed more rapidly in warm climates than in colder ones.

Whatever there is of inaccuracy in this short paper will I am persuaded meet with indulgence both from you and from the Society, whilst whatever truth is brought to light thereby will be received and adopted. I therefore venture to deliver it into your hands without hesitation. I am, &c.

(b) The ages of modern buildings are easily known, and there are none but what have iron rails or bars about them exposed to the weather. If the rain drops from them on Portland or any gritty stone, it becomes harder. The length of time such stones have been subjected to this process may easily be known, and the effects produced in them may be verified by repeated comparisons of different fragments.

(i) See CROUSTEDST's Mineralogy, p. 45.

I have added a few rough sketches to explain what has been said in this letter.

FIG. I. Represents the mass of concreted sand and rope from the coast of Lothian.

AB shews where there is one impression of a part of the iron ring.

CD shews where there is also another impression of the ring; and

EF shews where there also remain some impressions of bits of untwisted rope, so that this whole mass seems to have been formed within the circumference of the ring.

FIG. II. Represents a transverse section of the petrefaction within the wooden pipe, from the coal mine in Somersetshire; and

G shews the place of the point of the nail, and the regular curvilinear projection of the petrefaction around it, regularly throughout the whole progress.

FIG. III. Is a sketch of the gun, shewing the parts to which the incrustation adhered.



Fig: I.

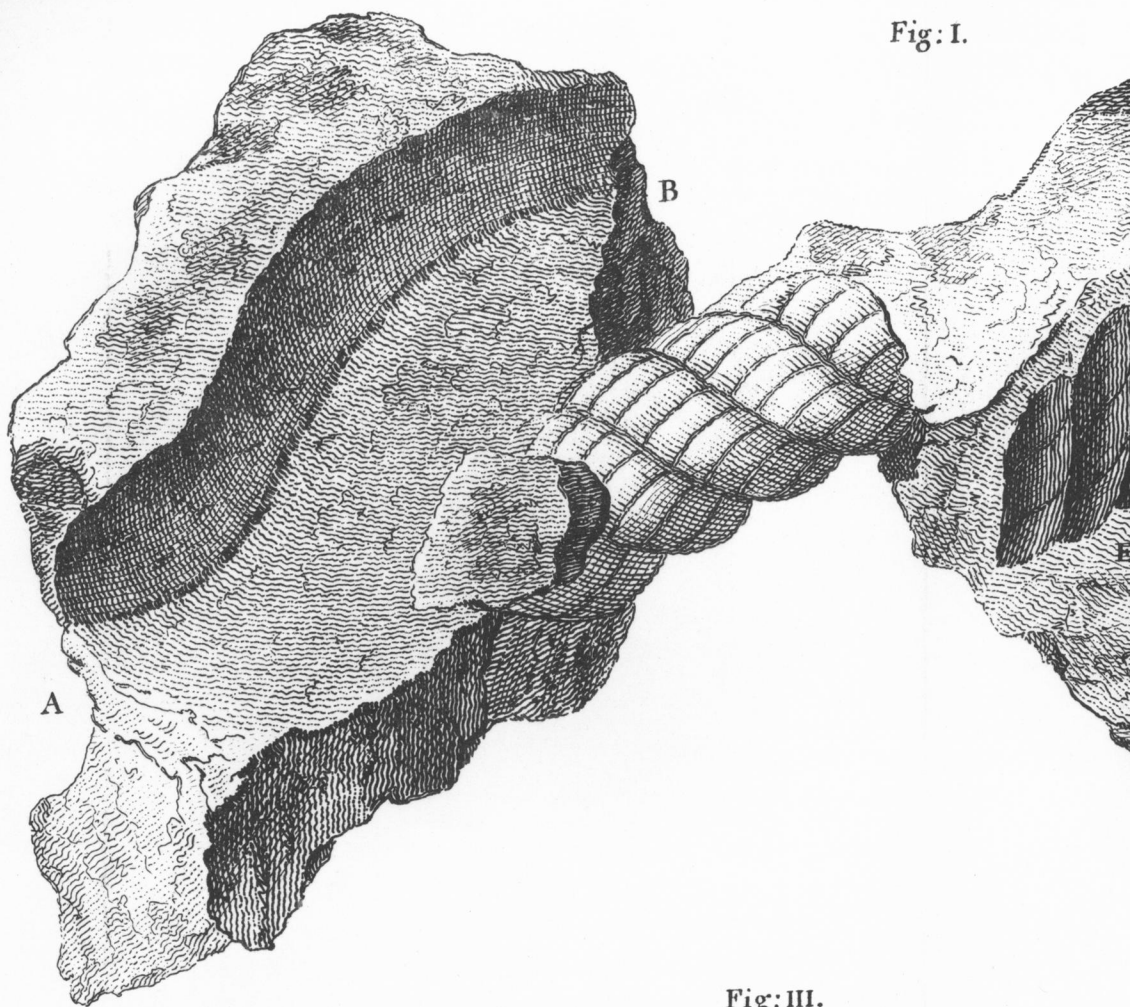


Fig: III.

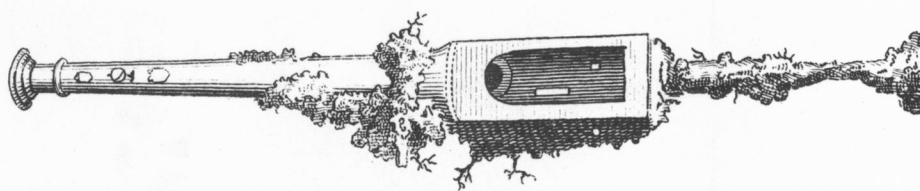


Fig: I.

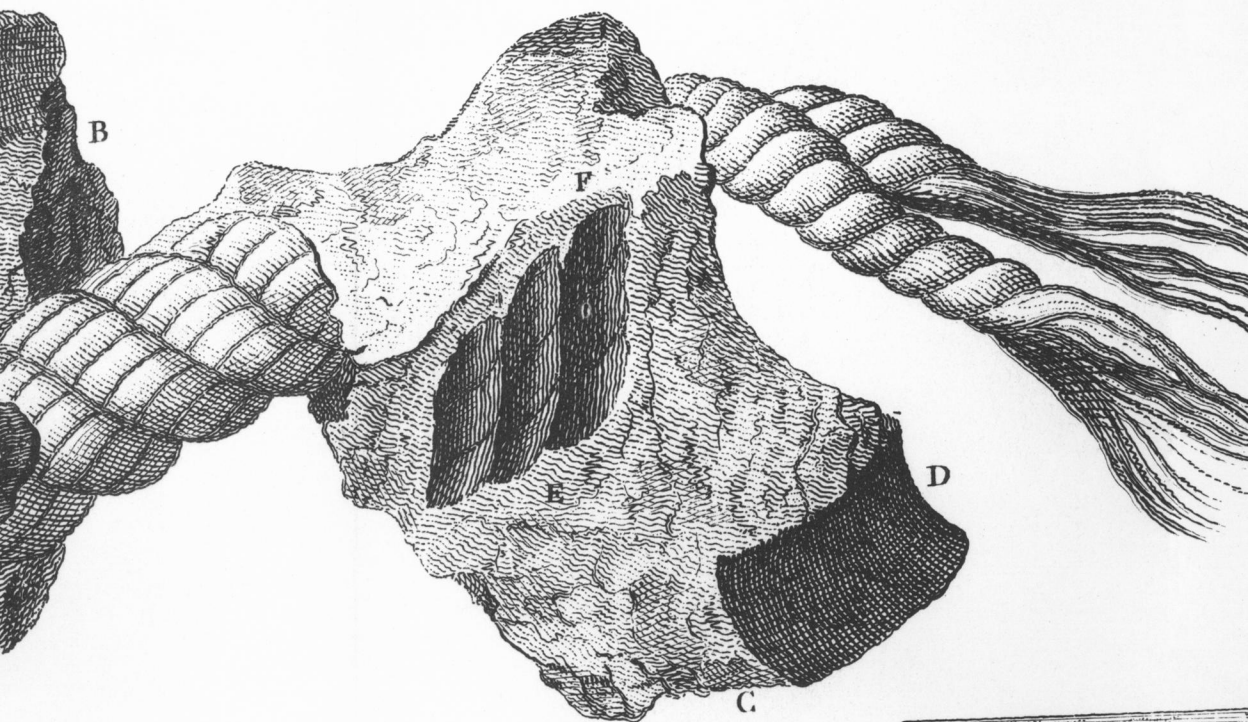
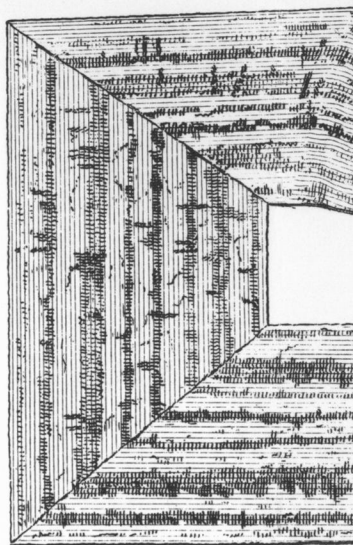
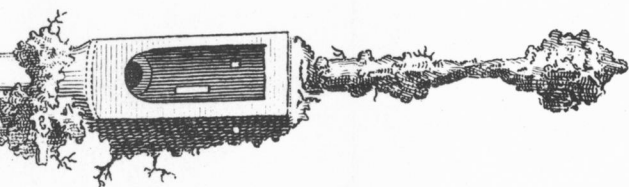


Fig: III.



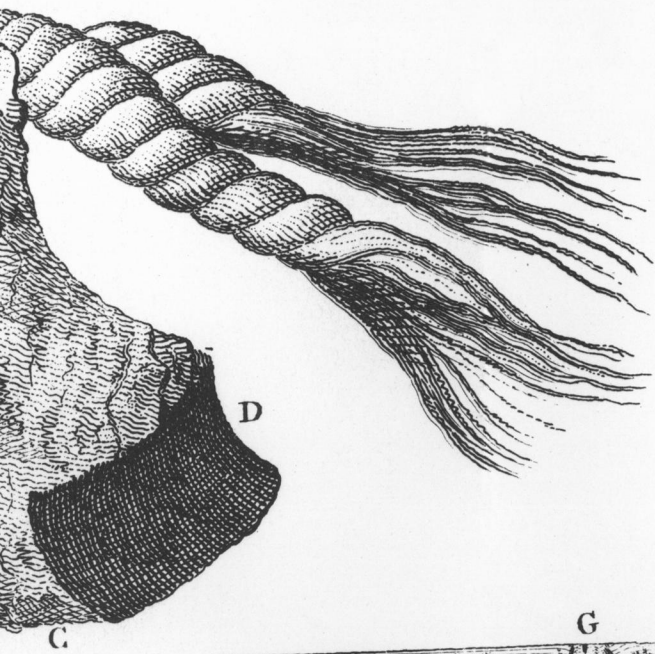


Fig. II.

